

# Building Greenhouse Gases

## Teacher notes

Give your students hands-on experience with greenhouse gas molecules, and help them understand how these molecules keep our planet warm.

**Age group:** KS3 and KS4

**Timing of activity:** Approx. 35 minutes

**Number of students:** Up to 30 students

### Overall learning outcome:

Students discover which gases are greenhouse gases – and how they affect Earth's energy budget.

## The activity

### Introduction

Overview: 'In this activity, we will be looking at greenhouse gases, and how they keep our planet warm.'

## Part 1

Atoms and molecules in the air (approx. 10 minutes)

### Learning objective:

- To revise/give an overview of the meaning of atoms, molecules, elements and compounds.
- To understand that molecules are made of two or more atoms, and that there's a variety of different molecules, named according to their constituent atoms.

### What to do:

1. Tell the students to take a deep breath. In that single breath there are trillions of atoms and molecules. Today the students are going to make models of some of these atoms and molecules.
2. Show the students the different-coloured balls of modelling clay, explaining that each colour represents *atoms* of a different *element*. Using the student sheets, get your students to fill in the atom key as follows (use this as a revision exercise or you can tell them):  
  
RED = oxygen; BLACK = carbon; PURPLE = argon;  
WHITE = hydrogen; BLUE = nitrogen
3. Ask students to use the atom key to identify the *molecules* of the different gases (some of which are *compounds*), plus the atom of argon, and label them on the student sheet. You can also ask them to try writing down the formula for each one – for example, water has two hydrogen atoms and one oxygen, so it is H<sub>2</sub>O.

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## Part 2

Model the atoms and molecules (approx. 10 minutes)

Learning objectives:

- To understand how the bonds between atoms give each molecule a particular shape and different modes of vibration.
- To know that carbon dioxide, methane and water vapour are greenhouse gases, and argon, nitrogen and oxygen are not.
- To understand that greenhouse gases are made up of more than two atoms.

What to do:

1. Divide the students into groups of two or three. The students then use modelling clay, cocktail sticks and cable ties to make models of six molecules present in the atmosphere. They use the student sheet as a guide.
2. Explain that the sticks and ties represent bonds.
3. Use the PowerPoint presentation (up to and including argon) to show the clues in turn. When the students think they know which element or compound is being described, they should hold up the relevant model.
4. Get the students to put the molecules in two piles: greenhouse gases and non-greenhouse gases. Investigate how the differently shaped molecules can vibrate in different ways. Discuss what the molecules in each pile have in common.

The most significant greenhouse gases:

- Have more than two atoms
- Tend to include different atoms (they are *compounds*)
- Have 'wobbly' bonds (i.e. bonds that allow the atoms to vibrate to and fro) – see ['An important note about the science'](#)

## Part 3

Planet warm-up (approx. 10 minutes)

Learning objective:

- To understand how greenhouse gases increase Earth's temperature.

What to do:

1. Explain that warm things give off heat radiation (infrared radiation) – and that includes Earth, which is warmed by the Sun. Earth's infrared radiation 'radiates' into space.
2. Split the group in two: two-thirds, 'HEAT', will play the role of infrared radiation leaving Earth, bound for space; the other third will play the role of 'GASES' in Earth's atmosphere.
3. The GASES group carry non-greenhouse gas models – N<sub>2</sub>, O<sub>2</sub>, Ar – and assemble loosely in the middle of the room. The HEAT group start in the corner of the room, to represent the warmed Earth. One by one the members of the HEAT group move from the corner out into the room ('into space'). As they walk, they say 'Wobble'. As they pass the GASES, the gases say 'No!' The HEAT group all escape into space.
4. Now, get each member of the GASES group to pick up a greenhouse gas model. Repeat step 3, but this time as the HEAT group say 'Wobble', the GASES group say 'I'm wobbling'. The GASES group send HEAT either back to the corner ('to Earth') or into the room ('into space'). It becomes clear that now there is less heat being lost to space, and Earth's temperature will rise.

## Part 4

Wrap up (approx. 5 minutes)

Recap what you have covered in the session, using the last two slides of the PowerPoint presentation, which explain how the various gases differ, and how heat energy is absorbed and re-emitted by greenhouse gases.

**Put this session in the wider context of climate change – see the background science document for more information.**

Some ideas for discussion:



Ask the students if they think that it would be best if there were no greenhouse gases in our atmosphere (get them to vote with a show of hands). Actually, without the greenhouse effect, Earth would be about 30 °C colder (average temperature of -15 °C). This is much too cold for life as we know it to exist. The greenhouse effect is a natural phenomenon. Greenhouse gases are needed in order to create a life-supporting atmosphere.

But increasing the amount of greenhouse gases in the atmosphere causes the planet to warm. Greenhouse gases are produced by natural and human activity. Concentrations of carbon dioxide, methane and nitrous oxide gas in the atmosphere have increased as a result of human action. Do the students know why this could be a problem?

Greenhouse gases include:

- Water vapour
- Carbon dioxide
- Methane
- Nitrous oxide

## An important note about the science

The mechanism by which greenhouse gas molecules absorb infrared radiation is actually more complicated than just 'wobbling'. The wobbly bonds mean that atoms can shift their relative position in the molecule.

Note that the cable ties in this activity would be better as springs, since atoms can move closer and further away from each other, as well as up and down (see the diagram below, which shows the different modes of vibration of a carbon dioxide molecule).

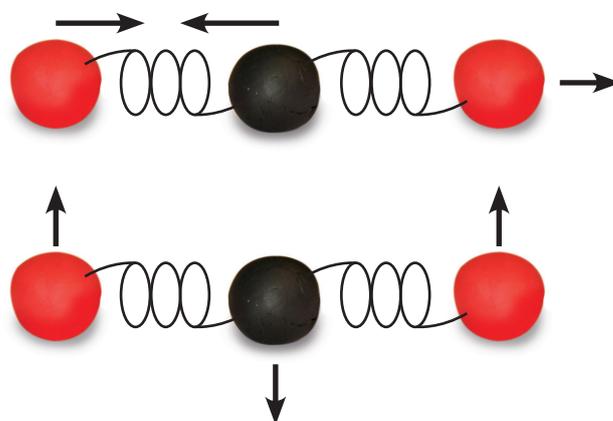
The result of all the wobbling is an unequal distribution of electric charge in the bond – a 'dipole moment'. The infrared radiation is an oscillating electromagnetic field, which interacts with the dipole moment, making the molecule jiggle in time with it – and absorbing some of its energy.

It's still valid in the activity to say that the greenhouse gases absorb heat radiation because they have 'wobbly' bonds. The main point is that they absorb and then re-radiate heat radiation that would otherwise have passed through the atmosphere and out to space.

Different modes of vibration of a carbon dioxide molecule



This mode produces no dipole moment because the vibrations are symmetrical.



## You will need...

- Student sheet: one per student
- Greenhouse Gas Molecules PowerPoint presentation
- Climate science: background briefing document for teachers

### Per group:

- Modelling clay – red, black, blue, purple and white
- Each atom is a small ball (about 15 grams)

75 grams of red = 5 red atoms (oxygen)

30 grams of black = 2 black atoms (carbon)

30 grams of blue = 2 blue atoms (nitrogen)

15 grams of purple = 1 purple atom (argon)

90 grams of white = 6 white atoms (hydrogen)

- 2 cocktail sticks
- 7 lengths of cable ties (each cut to the same length as the cocktail sticks) – cable ties are available in some supermarkets and most DIY shops

### Advance preparation:

- Print out the student sheets and download the presentation
- Prepare materials for each group

## National Curriculum links

KS3 Science QCA (2007):

1.1 a; 3.2 a–c; 3.4 c; 4 c, d, g, k; How science works: Attainment targets 2, 3

KS4

Supports work in the AQA, OCR and Edexcel areas of climate and the environment.

## Science Museum links

For more information about climate science go to the Climate Science Info Zone.

[www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone)

The following animations are particularly useful to help prepare for or follow up the Building Greenhouse Gases activity:

- An animation explaining what the greenhouse effect is. [www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5.aspx](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5.aspx)
- A simple animation explaining how greenhouse gases absorb infrared energy. [www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point2.aspx](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point2.aspx)
- This animation explains how scientists know the world is warming, having collected evidence of the impact of the human-caused greenhouse effect. [www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/Exploringwhatmighthappen/2point1.aspx](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/Exploringwhatmighthappen/2point1.aspx)
- More detailed information about greenhouse gases. [www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point1.aspx](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point1.aspx)
- More about the work of scientists who, over the past 250 years, have contributed to our knowledge of the greenhouse effect. [www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point4.aspx](http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthsclimate/1point5/1point5point4.aspx)

**For this activity and many more, visit [sciencemuseum.org.uk/climatescienceresources](http://sciencemuseum.org.uk/climatescienceresources)**

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